Climate Research by K-12 Students: Can They Do It? Will Anybody Care?

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NOAA and NSF: Workshop on Student Climate Research

http://www.instesre.org/NSFWorkshop/index.htm

Workshop to Define Student Climate Research
November 17-19, 2010, NOAA, Silver Spring, Maryland

IESRE

A workshop sponsored by the *Institute for Earth Science Research and Education*, the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). (Click on logos for more information about these organizations.)

NASA Innovations in Climate Education (formerly Global Climate Change Education)

https://nice.larc.nasa.gov/   http://www.instesre.org/GCCE/GCCEHome.htm

Climate Science Research for Educators and Students (CSRES): Understanding Sun/Earth/Atmosphere Interactions

IESRE

A project sponsored by the *Institute for Earth Science Research and Education* and the National Aeronautics and Space Administration's Global Climate Change Education Project (Now renamed NASA Innovations in Climate Education (NICE)).

Challenges for climate scientists and science educators

1. Helping teachers and students (and everybody else, too!) understand the past, present, and future of Earth's climate – a major science undertaking for the 21st century.

2. Building an infrastructure that supports student inquiry and research in Earth/climate science (winning "the hearts and minds" of today's students).

3. Understanding how to separate "research" from "inquiry" and other kinds of hands-on learning experiences.

4. Designing authentic climate research projects that can engage students and teachers as full partners with scientists.

How are we doing?

- Common knowledge: By every international standard, the US lags behind other developed (and even developing) countries in student achievement in math and science.
- It is almost unheard of to find climate-related projects in high-level science fair competitions. (We're losing the hearts and minds.)
- There is virtually no professional infrastructure to support student climate science research.

- *The Global Competitiveness Report 2009-2010*.
  http://www.weforum.org/pdf/GCR10/Report/Countries/United%20States.pdf
- *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5,*
  National Academy of Sciences.
  http://www.nap.edu/catalog.php?record_id=12999)
- *National Assessment of Adult Literacy (NAAL):A First Look at the Literacy of America's Adults in the 21st Century.*
  http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2006470)

Student and scientist collaborative research partnerships

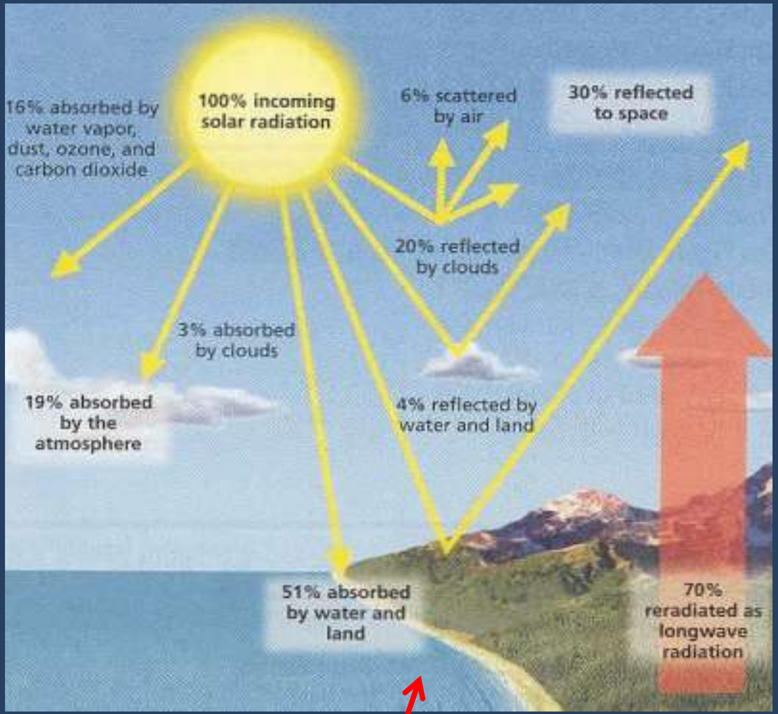
"Student and Scientist Partnerships (SSPs) are a new kind of collaboration between science and education based on the ability of students to contribute to scientific research. These partnerships offer science new ways of extending its community and hold the promise of revitalizing education by infusing authentic science into the school culture."

(cover page) Proceedings of The National Conference on Student & Scientist Partnerships, 23-25 October 1996. NSF/The Concord Consortium/TERC. http://ssp.terc.edu/ssp.html

Meeting the challenges: Start with the science

Collaborative climate research with students needs to be driven initially by *science* objectives. Once science objectives have been set, educational objectives will follow, but this process will not work the other way around for authentic student research.

Earth's radiative balance is one possible focus for defining student climate research. (See Climate Science Research for Educators and Students www.instesre.org/GCCE/GCCEHome.htm.)



Allison, Mead A., Arthur T. DeGaetano, Jay M. Pasachoff. *Earth Science*. Holt, Rinehart and Winston, 2006.

Hardly anybody understands these graphics!

When students and educators ask, *"Are we doing <u>real</u> climate research?"*

The "scientific interest" test:

"If students do a climate-related project in an appropriate way for an appropriate length of time, when they finish the project will any scientist care whether they did it or not?"

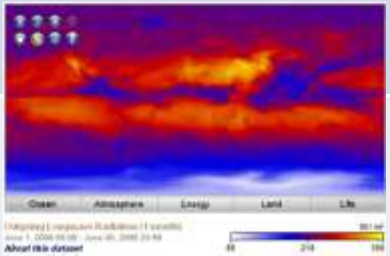
If the answer to this question is "yes," then the project *<u>could</u>* be real research. If the answer is "no," then the project cannot be real research.

Some possible student climate projects

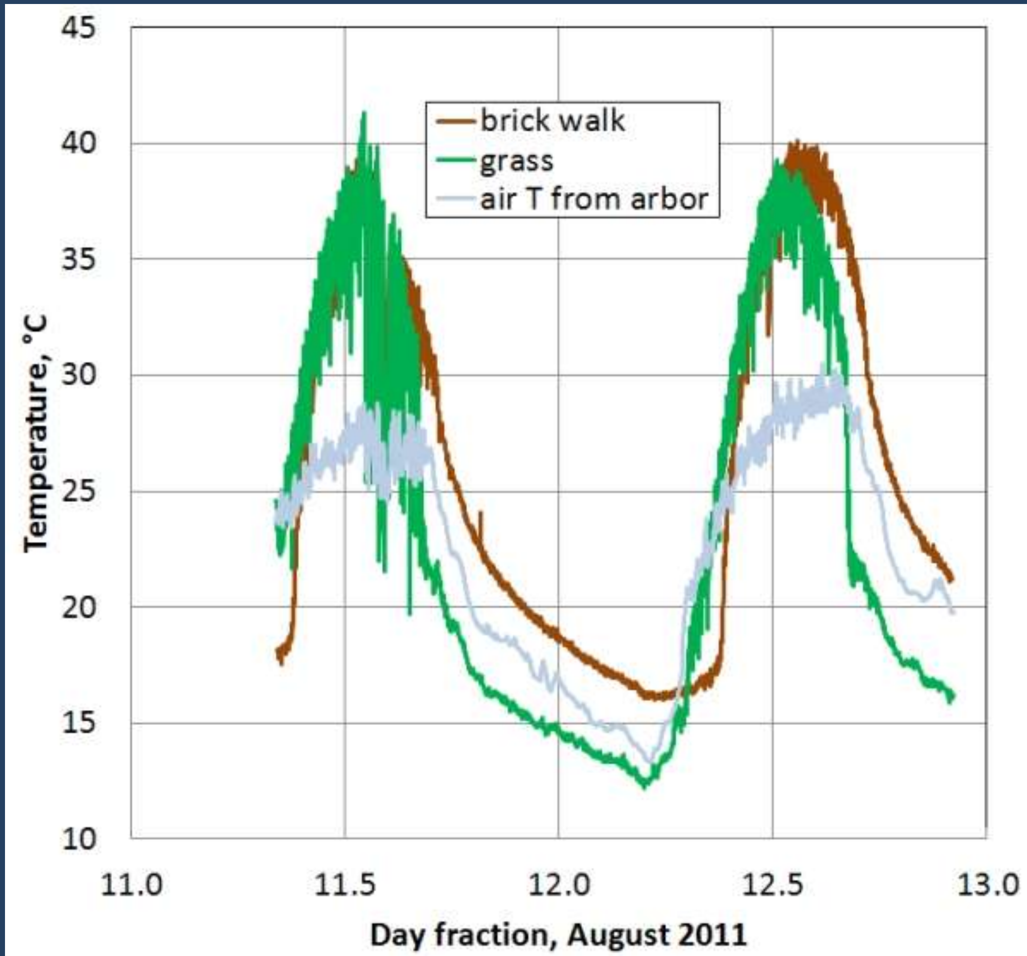
Some examples of appropriate data-based research topics include:

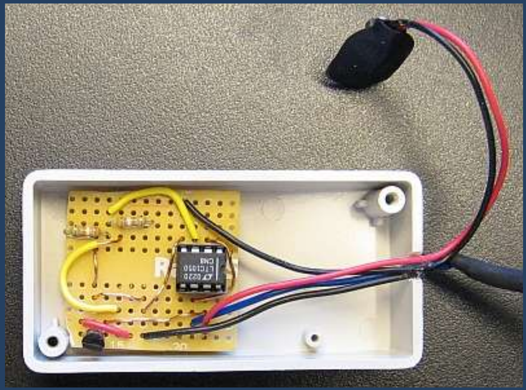
1. monitoring black carbon, atmospheric aerosols, and water vapor;
2. pyranometry at sufficiently high temporal resolution to study cloud patterns;
3. urban heat island and other microclimate effects;
4. monitoring benthic habitats and seafloor temperatures;
5. monitoring free-floating ocean buoys to help in the establishment of mobile marine sanctuaries;
6. monitoring surface reflectivity to generate local normalized difference vegetation indices;
7. tracking habitats for vector-borne disease carriers in developing countries.

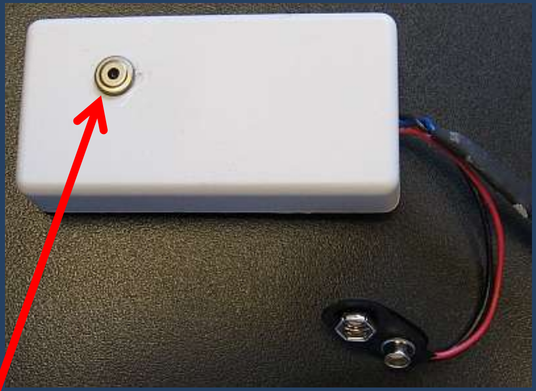
Some tools for student climate research

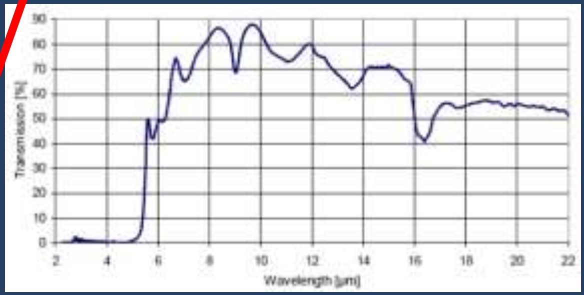
Measurement/Data	Source
Silicon-based pyranometer for measuring insolation (teachers and students can build it for $10). The performance of these instruments has been characterized as part of NREL's yearly radiometer BORCAL calibration project.	
Two two-channel radiometers for measuring surface reflectivity (broadband and near-IR). These detectors need only a relative calibration, rather than an absolute radiometric calibration.	
Inexpensive hand-held sun photometers for measuring aerosol optical thickness and water vapor. The visible-light sun photometers use LEDs as spectrally selective light detectors. The WV instruments use filtered photodiodes.	
Thermopile sensor for measuring surface thermal radiation. This device uses a sensor (~$20) like those found in handheld "non-contact" IR thermometers.	
Solar aureole photography for measuring atmospheric turbidity. This requires a simple fixture and a digital camera with manual settings.	
 Space- and ground-based views: AERONET, AIRNow, CRN, GPS-MET, My NASA Data, NEO.	

Surface radiating temperature







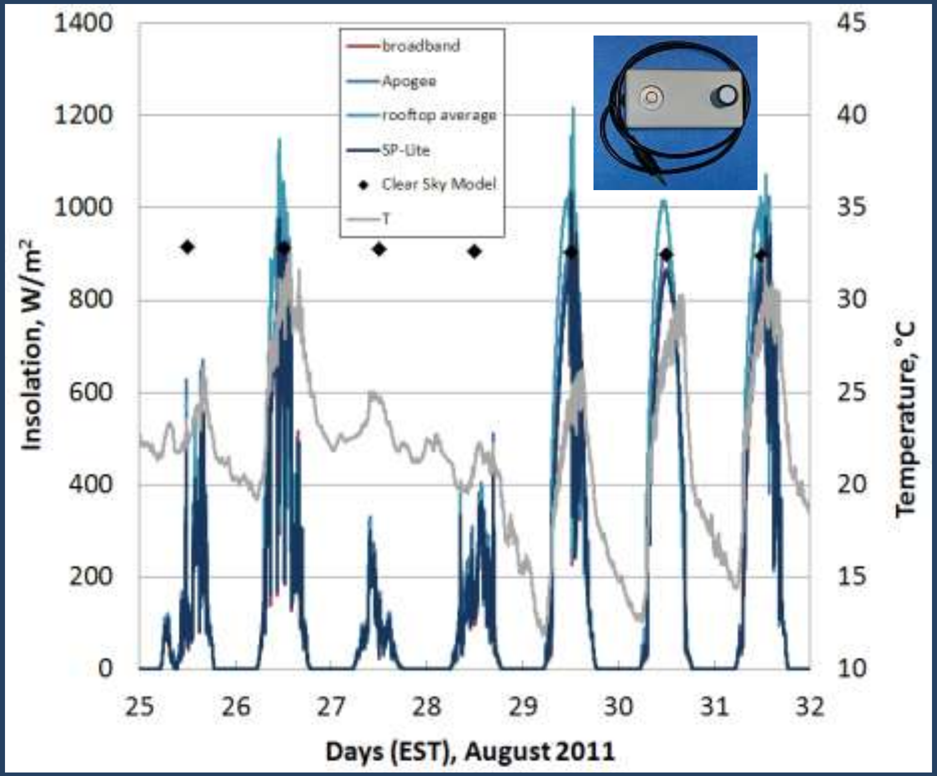


Excelitas TPS 1T 0134 OAA060 calibrated thermopile sensor (~$20)

Pyranometry and cloud statistics

Inexpensive pyranometer (~$10 in parts), can be built by students and teachers (always part of our teacher professional development workshops!). The performance of this instrument has been characterized during NREL's BORCAL projects.

For cloud statistics, see Duchon and O'Malley, *Estimating Cloud Type from Pyranometer Observations. JAM*, **38**, 132-141, 1999.



Worcester, PA (40°N, 75°W)
There are obstructions to the horizon at this site.

A student research project that needs equipment support

Measure the difference in broadband surface reflectivity between a vegetated (grass) surface and an asphalt or concrete surface (or artificial turf). This measurement relates to the impact of urbanization and other land use changes. What kind of equipment does this project need?

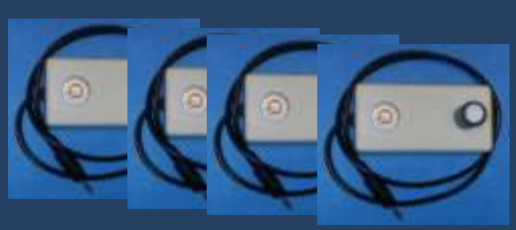
The least expensive commercial solution:

• 4 Apogee pyranometers, ~$800
• 2 Onset USB loggers plus software, ~$260

For a more sophisticated approach, separate VIS and near-IR

• 4 VIS/near-IR radiometers, 2 data loggers on loan from CSRES

This is an interesting project that is almost certainly beyond the financial means of schools and students.
It will never happen without equipment support!



If we care (and we should!), how can we help?

- **Step 1: Help to define a research plan.** Teachers typically have done no research themselves and have no experience with designing a research plan. Students may have some experience with following a “canned” experiment protocol, but not with gathering resources and designing an experiment to implement their own research plan.
- **Step 2: Establish a collaboration.** The collaboration should be based on a specific objective that meets a “scientific interest” test. It needs to spell out timelines, responsibilities, and rewards for all participants.
- **Step 3: Provide equipment and ongoing mentoring support.** Teachers and students need a high level of support to collect data appropriate for a competitive science fair or other research project. Appropriate levels of support will make the difference between an “educational experience” and authentic science with usable results.

In conclusion…

- Students can do real climate research if we are honest with them and their teachers about what is required.
- The current lack of support for student climate research needs to be overcome before we can engage students in meaningful research. If we, as scientists, care about engaging students in climate science, we must do much more to build this supporting infrastructure.
- Students and teachers need project ideas, equipment, and ongoing support in order to do authentic climate-related research.
- Does anybody care? *The answer to this question is up to us!*